DOCUMENT RESUME

ED 271 486 TM 860 383

AUTHOR Gilbert, Laurence C.
TITLE Inducement of Metacognitive Learning Strategies: Task Knowledge, Instructions, and Training.
PUB DATE Apr 86
NOTE 40p.; Paper presented at the Annual Meeting of the American Educational Research Association (70th, San Francisco, CA, April 16-20, 1986).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Academic Aptitude; Advance Organizers; Aptitude Treatment Interaction; Cognitive Processes; Cognitive Style; Higher Education; Learning Processes; *Learning Strategies; *Map Skills; *Metacognition; Performance Factors; *Recall (Psychology); Self Evaluation (Individuals); *Training Methods
IDENTIFIERS Scholastic Aptitude Test

ABSTRACT

Fifty-four high aptitude undergraduates and 46 moderate-to-low aptitude undergraduates were divided into four treatment groups and were given a pretest during which they learned and recalled a map of a small town in five successive trials. Two weeks later, each group was given a different treatment with a varying degree of explicitness of inducement to use a set of effective metacognitive learning strategies. Each learner completed questionnaires indicating their degree of use of each of 20 cognitive learning strategies. The results indicated that those learners who were given the most explicit instruction in successful metacognitive strategies performed nearly twice as well as the other three groups. Those metacognitive procedures involving the application of planning, monitoring, and evaluation behaviors were consistently preferred by successful learners. The use of these procedures was highly correlated with successful recall performance. The training treatment was equally successful for learners from two widely disparate college-age populations (differing by Scholastic Aptitude Test Scores). The results indicated that successful map learning depended on the application of metacognitive strategies. It was concluded that less successful learners could be trained to use these successful strategies, thus overcoming initial limitations. (Author/GDC)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED271486

Inducement of Metacognitive Learning Strategies: Task Knowledge, Instructions, and Training

Laurence C. Gilbert
Instructional Media Services
University of Nevada-Reno

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

X This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

L C. Gilbert

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)"

Presented at the annual meeting of the
American Educational Research Association
San Francisco
April, 1986

TM 860 383

ABSTRACT
Inducement of Metacognitive Strategies for Map Learning
Task Knowledge, Instructions, and Training

Laurence C. Gilbert, Ph.D
University of Nevada-Reno, 1986

Fifty-four high aptitude learners and 46 moderate to low aptitude learners were randomly divided into four treatment groups. Each group was given a pretest during which they learned and recalled a map of a small town in five successive recall trials. Two weeks later, each group was given a different treatment ranging along a continuum based on the explicitness of the inducement given to learners to use a set of effective metacognitive learning strategies. Each learner filled out self-report questionnaires indicating their degree of use of each of 20 cognitive learning strategies used for map learning.

The results indicated that those learners who were given the most explicit inducement of the use of successful metacognitive strategies (training) performed nearly twice as well as their counterparts in the other three groups. Those metacognitive procedures involving the application of planning, monitoring, and evaluation behaviors were consistently preferred by the more successful learners. The use of these procedures was highly correlated with the successful recall performance of the training group. The training treatment was equally successful for learners from two widely disparate college-age populations (differing by approximately four standard deviations in SAT scores).

The results indicate that successful map learning depends on the application of metacognitive strategies. Less successful learners can be induced to use these successful strategies, thus overcoming initial capacity limitations.

Introduction

Imagine a parent who suggests the following solution to the problem of students who are not successful in school:

> "Some students are successful at learning no matter what the teacher does, right? So why not just find out what the good learners do and teach the bad students how to learn in the same way?"

As educational researchers we learned long ago that instructional situations are so complex that such suggestions are usually too simplistic to be viable. Through our research we search for elegant solutions that manipulate the many conditions of instruction in order to optimize learning. We hope that our experimental theories will be prescriptive and thus serve as a "linking science" by providing simple solutions to everyday instructional applications (Glaser, 1976).

The General Theoretical Basis

Despite the inherent simplicity, the hypothetical layman's questions generally define the basis of the research described in this paper. From a researcher's standpoint, the layman is describing an instructional theory that places emphasis on the active role of the learner in the use and control of cognitive strategies, as opposed to theories that emphasize the manipulation of instructional materials or events.

Cognitive processes have been advanced as the common explanatory constructs which can form the basis for the integration of inquiry into aptitude, learning, and instruction. The recent proliferation of research dedicated to the examination of the role of cognitive processes in these three domains indicates a major paradigmatic shift within instructional theory and research (see

Anderson, Spiro, & Montague, 1977; Glaser, 1978; Glaser and Resnick, 1972; Klahr, 1976; O'Neil, 1978; Snow, Federico, & Montague, 1980). Shuell (1980) asserts that a theory of instruction now involves the explicit description of the relationship between specific teaching behaviors and the cognitive strategies and processes involved in learning particular content domains. Bovy (1981) places all instructional strategies on a continuum based on the amount of cognitive processing burden they carry for learners. This reformulation of our ideas about instruction implicitly suggests that it may, in fact, be possible to teach students to be more effective learners -- as opposed to the current emphasis on teaching only subject matter.

Cognitive Strategies and Instruction

Joseph Rigney (1978, 1980) outlined a comprehensive theory concerning cognitive strategies used by learners that suggests how cognitive strategies might relate to instruction. As visualized in Figure 1, learners can be conscious or unconscious of their use of strategies; control of strategies can be assigned by the students themselves or by the instruction. So-called "cognitive orienting tasks" are defined as instructional techniques that induce learners to use appropriate cognitive strategies. Such strategies could be assigned by the learner or assigned by the instruction. These inducements to use particular strategies can be embedded in the design of the instructional materials (e.g. inserted questions in text) or detached from the subject matter (e.g. instructions to use imagery) (see Figure 1).

Learner Awareness of Strategy	Student Controlled	Lesson Controlled
Conscious	A	B (Embedded or Detached)
Unconscious	C	D (Embedded or Detached)

Figure 1. Rigney's Categorization of Strategies

One ultimate goal of instruction should be category A: that is, to induce learners to be conscious of effective cognitive strategies so that they may eventually become competent enough in their use that they can unconsciously assign those strategies to themselves at the appropriate times (1980). Or, as stated by Winn (1982):

> Instruction involves the control of cognitive processes. It achieves this by inducing learners to use learning strategies (i.e. to apply mental skills) that are appropriate to the task at hand (p. 4).

This approach places a new emphasis on making the student a self-sufficient learner who can understand, monitor, and control his thought processes in relation to specific tasks (Heidt, 1980). Ideally the learner attains new processing skills and improves existing ones in response to both task demands which activate those strategies and direct instruction which trains those skills (Salomon, 1979). Activation of processing skills requires that the learners have already mastered the entire cognitive skill or strategy, and thus might be expected to help only successful learners who simply need to be reminded to use an existing skill. The training (or "supplantation") of cognitive skills offers the additional possibility of helping less successful students who

might not naturally possess all the prerequisite skills necessary for the use of successful strategies. If this is the case, then the training of cognitive strategies offers the promise of meeting one of the critical needs of contemporary education -- to help the low ability student to improve his or her capacity to learn.

A Strategy Training Model

An excellent model for both the identification of effective learning strategies and the subsequent inducement of the active control of such strategies by learners has been provided by Perry Thorndyke and Cathleen Stasz in a series of map learning studies completed for the Office of Naval Research (Stasz, 1980; Stasz and Thorndyke, 1980; Thorndyke; 1980; Thorndyke and Stasz, 1979, 1980). The approach to cognitive learning strategies used within these studies would fall within category B of Rigney's model (Figure 1); that is, they concern conscious, lesson contolled cognitive procedures that are detached from the instructional material itself.

Thorndyke and Stasz first used protocol studies to identify a set of nineteen map learning strategies used by adult students, classifying those strategies as being "successful" or "unsuccessful" for map learning. They then explicitly trained those strategies to another group of learners, using a pretest-posttest design to examine both the change in the use of the learning procedures and the changes in performance following the training. The results indicated that explicit training in the use of predefined effective cognitive learning strategies resulted in significant gains in map recall performance, when compared to the

training of neutral or ineffective strategies.

The Current Study

The current research expanded on the excellent base provided by Thorndyke and Stasz by refining the previous studies in order to answer two additional questions: a) which of the many types of available cognitive strategies are the best determinants of success on the map learning task?; and b) what level of instructional intervention is necessary to get learners to effectively utilize those strategies?

Data Source: The data was collected from 56 undergraduate participants from the College of William and Mary and 44 undergraduate participants from Hampton Institute. The subjects were purposely selected from two widely disparate college enrollments (approximately four standard deviations difference in average SAT scores) in order to test the hypothesis that the effective use of metacognitive strategies is not dependent upon entering ability. All students were tested in groups on their respective campuses.

Methods: This study utilized a 2X4 factorial design with one four-level between groups factor (i.e. method of inducing effective map learning strategies) and one repeated measure (i.e. recall of map attributes on the pretest and posttest) (see Figure 2). The stimulus materials consisted of four maps of fictional small towns, including both line drawing symbols and labels. An example is provided as Figure 3.

The above learners were randomly divided into four treatment groups. Each learner took part in two separate group research sessions. The first session lasted approximately one hour and

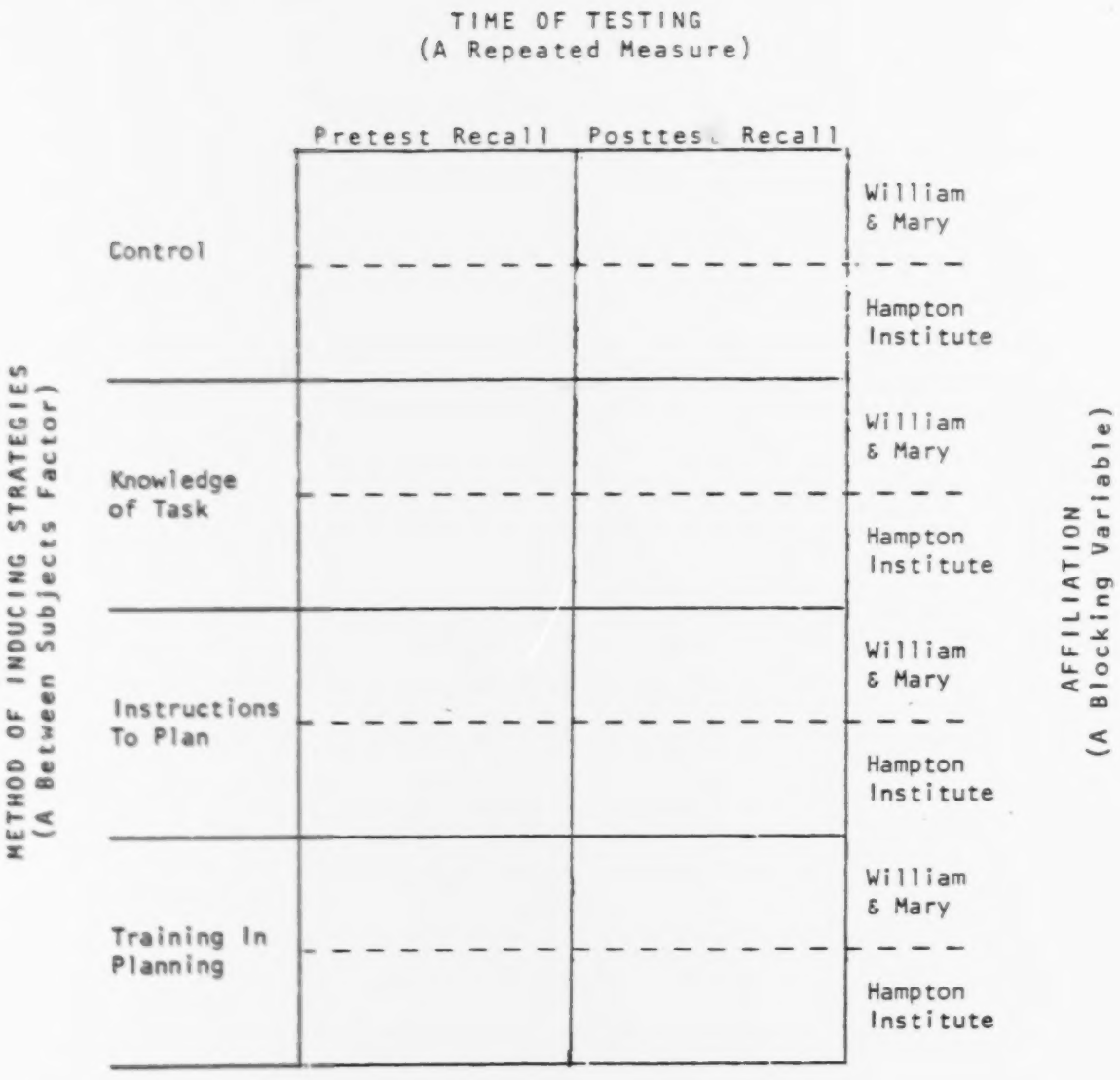

Figure 2: Experimental design with one between-subjects factor, one within-subjects factor (a repeated measure), and one categorical blocking variable.

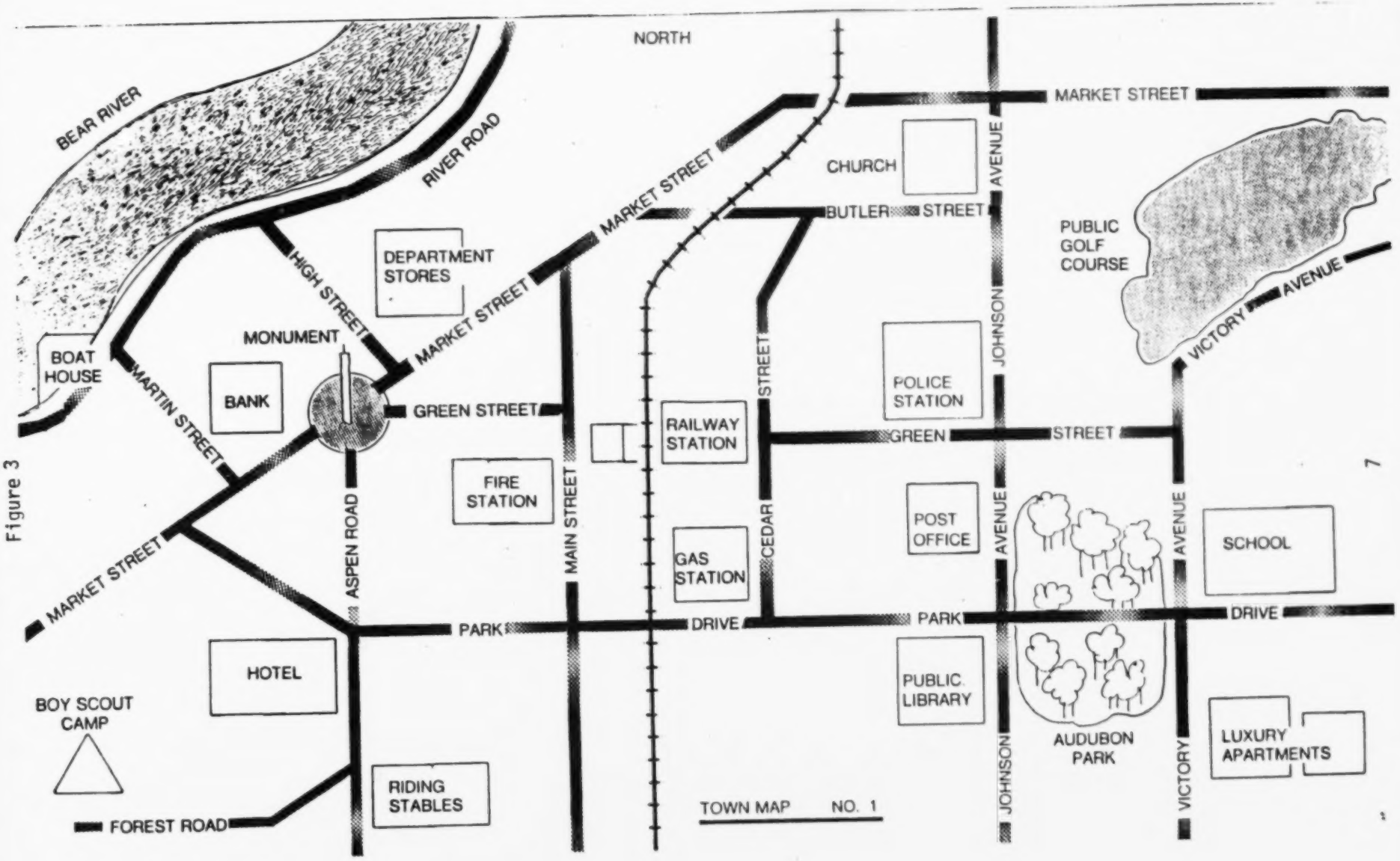
NORTH
BEAR RIVER
RIVER ROAD
MARKET STREET
CHURCH
AVENUE
BUTLER STREET
PUBLIC GOLF COURSE
VICTORY AVENUE
HIGH STREET
DEPARTMENT STORES
MARKET STREET
MONUMENT
BOAT HOUSE
MARTIN STREET
BANK
GREEN STREET
STREET
POLICE STATION
JOHNSON
RAILWAY STATION
GREEN STREET
FIRE STATION
MAIN STREET
CEDAR
POST OFFICE
AVENUE
AVENUE
SCHOOL
MARKET STREET
ASPEN ROAD
GAS STATION
PARK DRIVE
PARK DRIVE
HOTEL
PUBLIC LIBRARY
BOY SCOUT CAMP
AUDUBON PARK
LUXURY APARTMENTS
JOHNSON
VICTORY
RIDING STABLES
FOREST ROAD
TOWN MAP NO. 1

Figure 3

included a pretest of map learning ability and a psychometric test of visual memory ability. The second session (given about two weeks later) lasted approximately one and one-half hours and included the respective group treatments, a practice session, and the posttests.

During the first session, the learners initially completed a psychometric test of visual memory ability (Ekstrom, French, & Harman, 1976). They were then told that their task was to learn a map well enough to both reproduce it and to answer any questions about it, using any techniques that they knew. The learners then studied the first map in five separate two minute intervals, reproducing that map as accurately as possible on a blank piece of paper after each study trial (with from 5 to 7 minutes allowed for reproduction).

At the start of the second session each group was told that they would be given some additional information that would help them to perform better than they had on the pretest map. The treatment presentations ranged in length from 7 minutes for the control group to 15 minutes for the training group. Following the treatments, each group was given three practice periods consisting of two minutes for study and four minutes for recall of a second map. The instructions for the practice sessions emphasized that the learners should try very hard to use those study techniques that had just been presented to them. They were told to use this time to both reflect on their strategies or to reproduce the maps -- if they felt that this would help their understanding and application of those strategies. Before, during, and after the practice sessions learners were given opportunities to ask questions about

the directions given to them.

As treatments, the control group was told to continue using its own strategies; the "task" group was given examples of the posttest comprehension questions and told to self-generate strategies useful for answering such questions; the "instructions" group was given general information about effective strategies and told to self-generate a set of specific strategies; the "training" group was given explicit instructions, training, and modeling in the use of a specific set of metacognitive learning strategies.

Immediately following the treatment and practice sessions, subjects in each group were told to study a third map using the strategies that they had just practiced. The procedure for administration of the five study-recall periods allowed was identical to that used for the pretest session. At the end of the study-recall periods all learners completed a 15 item comprehension test and then filled out two strategy use questionnaires (one for the pretest and one for the posttest) that indicated their frequency of use of 20 encoding, spatial, attentional, evaluation, and planning strategies. In order to increase the reliability of the self-report answers concerning strategy use, all subjects were required to look at their own respective pretest and posttest map reproductions in order to confirm (whenever possible) the use of a given strategy.

Each subject's map reproductions were scored for accuracy of recall of verbal, spatial, and complete map elements using a set of decision rules devised by Thorndyke and Stasz (1979). An additional set of decision rules specific to the actual stimulus materials used in this study was also devised, in order to avoid any possible inconsistency in scoring the maps. Two examples of student map

reproductions are included as Figure 4.

The main criterion for successful learning was recall of spatial, verbal, and complete map elements. A comprehension test involving real-life situations related to the map served as a validity check on these recall measures.

Rationale for the Study

The Appropriate Level of Learning Strategies: One major goal of this study was to pinpoint which of the many types of cognitive learning strategies are most important for map learning. Table 1 compares the cognitive strategies used in the current study with those utilized by Thorndyke and Stasz. As the table indicates, Thorndyke and Stasz emphasized encoding strategies (especially spatial encoding) and attention strategies. The encoding strategies specifically relate to the mode of representation used by the learner to store the map information in memory. The attention strategies refer to the ability to selectively sample and partition map information. Stasz' 1980 study found that successful learners tended to use so-called "global attention strategies" as a means of planning their approach to segmenting and scanning the maps to be learned. Those learners who used the more systematic attention strategies tended to be more successful at the map learning task.

The current study hypothesized that the encoding and attention strategies identified by Thorndyke and Stasz are necessary, but not sufficient, for success at map learning. For example, learners in the Stasz study had a choice of three effective global attention strategies. In order to be as successful as

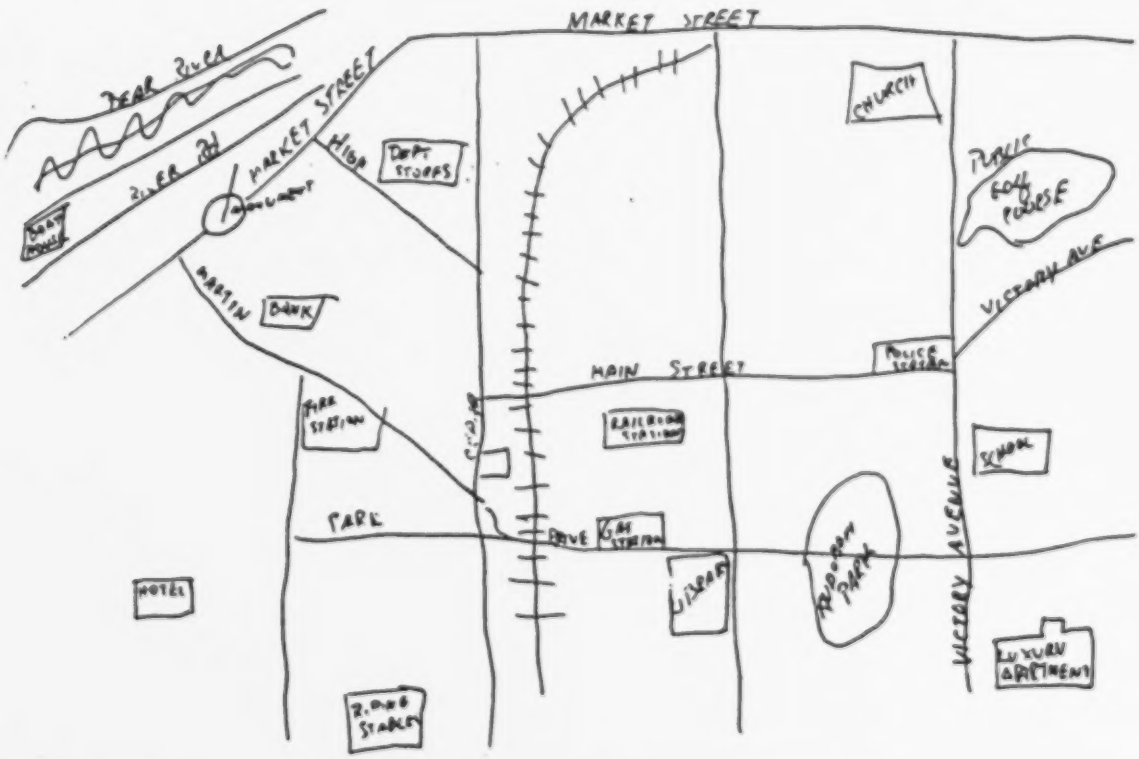

Figure 4: Sample Map Reproductions.

BEST COPY AVAILABLE

Table 1

Comparison of the Thorndyke and Stasz Strategies With The Strategies Used In The Current Study

Thorndyke and Stasz	The Current Study
Encoding Strategies	Neutral Strategies
Rehearsal	Rehearsal
Element naming	(deleted)
Association 1	Association 1
Association 2	Association 2
Association 3	Association 3
Mneumonics	Mneumonics
Counting	Counting
Labeling	Labeling
Visual imagery	
Pattern encoding	Spatial Strategies
Relation encoding	Visual imagery
	Pattern encoding
	Relation encoding
Attentional Strategies	Ineffective Strategies
Spatial partitioning	Random sampling
Conceptual partitioning	
Random sampling	Attention Strategies
Stochastic sampling	Spatial partitioning
Systematic sampling	Conceptual partitioning
Memory directed sampling	Stochastic sampling
	Systematic sampling
Evaluation Strategies	
Evaluation	Global Strategies
	General evaluation
Planning Strategy	Unlearned elements
	Immediacy
	Planning
	Completion

possible on the map learning task, learners would have had to do the following: a) characterize the problems inherent in the map learning task; b) decide which of several possible attention strategies to use; c) gauge the limitations of their own abilities at using the strategies and how to surmount them; d) specifically plan the use of the strategies chosen to accomplish the entire task; e) monitor and evaluate the effectiveness of the strategies chosen; and f) eliminate any ineffective strategies and substitute others at the appropriate time.

All of these additional tasks represent "metacognitive" activities involving the conscious planning, monitoring, evaluation, and supervision of the use of specific learning strategies (see Brown, 1977, 1978; Flavell, 1976, 1979). These loosely defined strategies have been referred to by a number of labels, including: strategic variables (Snow, 1976), executive processes (Carroll, 1976), top-down strategies (Bobrow and Norman, 1975), and self-directional learning strategies (Rigney, 1978).

Cognitive psychologists have largely concentrated on developing microscopic descriptions of the performance of complex tasks in order to build up a set of simple components which might be combined to explain intelligent behavior (Estes, 1975). Those operating within this context de-emphasized the role of voluntary strategies in order to concentrate on the structural components of human thought and performance.

Snow (1976) has pointed out the limitations of the microscopic approach in describing real-world situations: "While simple cognitive models may provide parsimonious starting points, we expect them to be far too simple in their account of individual

differences in instructional learning." He suggests that as task complexity increases so does the importance of the executive planning and controlling (i.e. metacognitive) processes. Such a macroscopic approach seems also to have more ecological validity for practical instructional concerns, since it accounts for the goal-directed "adaptive performance of great elegance and rationality" which characterizes the performance of real-world tasks (Moray, 1978).

Of direct interest to the study of metacognition in instruction are previous analyses of the cognitive learning strategies utilized by successful learners during the performance of real-world tasks (Curcio and Smith-Burke, 1982; Derry, 1985; Newell and Simon, 1972; Simutis, 1982; Thorndyke and Stasz, 1979). This type of research has consistently identified the tendency of successful learners to use highly systematic, planful learning strategies which specifically include metacognitive components. Both Norman (1977) and Brown (1978) noted that the training of such executive strategies may bring more success than the training of more specific cognitive strategies, because the metacognitive processes control the application and "debugging" of the simpler processes.

The Thorndyke and Stasz studies included only two explicit metacognitive strategies in the set of effective strategies taught to their training group (memory-directed sampling and evaluation). Yet both the protocol studies (Thorndyke and Stasz, 1979, 1980) and the Stasz study (1980) indicated that successful learners carefully planned, monitored, evaluated, and controlled their learning. In order to specifically account for this behavior, the current study concentrated on an expanded set of five purely metacognitive stra-

tegies. Along with general evaluation and planning skills, the research added: a) "immediacy", to reflect the tendency of successful learners to immediately reevaluate unlearned elements after each recall trial; and b) "completion" to reflect the tendency of good learners to consistently use and monitor a strategy until it has met its intended goal. "Memory-directed sampling" was relabeled "unlearned elements" and reclassified as a metacognitive strategy, since it seemed indicative of the tendency of successful learners to carefully evaluate their performance on a periodic basis.

Inducing Strategy Use: A major assumption behind this research is that the goal of instruction is to induce learners to use appropriate learning strategies for the task at hand. Thus a major goal of this study is to prescribe practical methods for getting learners to adopt those strategies which are most effective. Mathews, Hunt, and MacLeod (1980) demonstrated that it could be rather easy to train subjects to adopt selected cognitive learning strategies. Such research began to indicate to instructional researchers that learners themselves might possess the capacity to improve their own learning ability.

This emphasis on learner controlled capabilities offers two distinct advantages over more traditional approaches. For one thing, if effective instruction depends solely on the manipulation of teaching activities and materials then researchers face the problem of adapting instruction to a virtually infinite number of task variations and learner characteristics (Salomon, 1971). Secondly, the training of strategies avoids the potential problem of making learners so dependent on instructional compensations that they

become unable to develop those skills needed to cope with everyday problems outside the school (Boutwell & Barton, 1974; Merrill, 1975; Heidt, 1980).

On the other hand, if learning strategies can be trained the learner himself begins to exert far more control over the teaching/learning process. Theoretically, a learner could over time build up a repertoire of transferable effective learning strategies. This conception allows a leap from the previous adaptive models to the so-called "transferential" model (Heidt, 1980). This new model of instruction asserts that the learner himself can decide which means of processing are appropriate to a given task.

The Method of Inducement: The second major goal of this study was to determine just how explicit and directive instructional inducements of strategy use have to be to ensure success. Do learners have to be exlicitly conscious of the use of strategies? Can students induce and control their own strategies or are specific instructional inducements necessary? Should such inducements be embedded in instructional materials or detached from them?

Much previous research suggests the need for explicitly inducing learners to use effective cognitive strategies (see Alesandrini, 1981; Brown, 1977, 1978; Gick and Holyoak, 1980; Sternberg and Weil, 1980; Weinstein, 1977). Most learners seem singularly unable to identify, alter, and control their use of cognitive strategies without specific training in their use.

Thorndyke and Stasz found that specific training in the use of effective strategies (i.e. detached, lesson controlled

inducement) could lead to significant improvement in map recall performance. In order to find out if less intrusive levels of inducement could also cause successful use of metacognitive strategies, the four treatment groups in the current study were given inducements that ranged along a continuum based on the amount of processing burden carried by the learner (Bovy, 1981; Rigney, 1979, 1980).

The control group treatment was a student controlled, application of strategies (category A from Rigney, Figure 1); the "task" group treatment was an embedded, lesson controlled inducement of conscious strategies (category B, embedded); the "instructions" treatment represented a detached inducement that included elements of both lesson control and student control (categories A & B, detached); and the "training" treatment was a detached, lesson controlled inducement with explicit modeling of strategy use (category B, detached).

Aptitudes and Strategy Inducement: Das, Kirby, and Jarman (1975, 1979) found that low aptitude learners lacked the spontaneous use of specific control and monitoring strategies regularly used by high aptitude learners. However, a series of studies completed with a widely varied group of Canadian school children showed that modeling, instructions, and feedback in the use of successful metacognitive strategies could lead to a significant improvement in the ability of low aptitude learners to succeed on standardized aptitude tests. This finding suggested that training in the use of metacognitive strategies might be able to overcome the initial capacity limitations of poor learners. In order to test this finding the learners in this study were

selected from two widely disparate college populations, with affiliation added as a blocking variable in the research design.

Maps as Stimulus Materials: Both this study and the Thorndyke and Stasz studies utilized small city maps as stimulus materials. Much of the reasoning behind choosing maps as the stimulus materials for my research is simply practical -- great strides have already been made in our understanding of learning strategies through their use by Thorndyke and Stasz. However, the justification for using maps goes beyond mere practicality. Polya (1967) cited a map learning task as an example of expert problem solving. Gagne' (1965) stated that map learning tasks "bear a close formal resemblance to problems that are solved by students" (p. 54). Maps also seem to share a number of surface characteristics with other types of media, including spatially organized diagrams (Gropper, 1970), proceduralized instructions using pictures and words (Booher, 1975), flow diagrams (Holliday, 1976), graphics in texts (McDonald-Ross, 1977), and block-word diagrams (Winn, 1980).

As can be seen in Figure 3, the maps included both spatial and verbal information. In order to check the validity of the recall of these attributes as a measure of successful real-world learning, a comprehension test was devised to measure knowledge of facts, knowledge of rules and principles, and the ability to make applications. An example of the first type of question (i.e. location) is: "If the map were divided into four equal parts, the Public Library would be located in the a) upper left, b) lower left, c) upper right, and d) lower right." A typical principle question (i.e. route finding) is: "What is the shortest route from

the Luxury Apartments to the Golf Course?". Finally, an example of an application question (i.e. problem solving) would be: "There is a robbery in progress at the Hotel. A train is blocking Park Drive. How can the police get from their station to the Hotel by the shortest route?" As the samples indicate, each type of question requires progressively more integration of the map elements.

Strategy Use Questionnaires: Since the entire research study focused on the identification and inducement of cognitive strategies, an instrument to accurately assess strategy use both before and after treatment was necessary. Thorndyke and Stasz had previously demonstrated the viability of self-reporting techniques based on introspection. Although such measures are often considered unreliable, there were a number of checks available on the use of self-report questionnaires for strategy use assessment: 1) the strategies listed had been carefully observed in five previous studies; 2) the use of most strategies could be confirmed by analysis of the reproduction of the maps across five recall trials; 3) specific examples of each strategy were included to eliminate confusion; 4) responses given on the questionnaires could be compared to a priori predictions concerning strategy use; and 5) indicated increases in the use of effective strategies could be correlated with objective improvement in map recall performance.

Figure 5 provides an example of a strategy use question. Note the use of an explicit example of the use of the strategy.

17. I was careful to devote attention to areas that I had not yet learned well, and did not spend much time reviewing information that I already knew.

Example: You noticed that you knew the buildings well, but you kept getting the streets all mixed up, so you decided to devote more attention to the streets and not to review the buildings until the last trial.

0	1	2	3	4	5	6
NEVER	ONCE	OCCASION-ALLY	FREQUENTLY		MOST OF-THE TIME	EVERY TRIAL

Figure 5: Example of a strategy-use question.

Research Hypotheses:

The following eight a priori hypotheses were established, based on the discussion of theory outlined above:

1) Those learners who perform well on the pretest of map learning will indicate that they used more of both the four attention strategies and the five metacognitive strategies than will those learners who did not perform well.

2) Those treatments with the more explicit inducement of metacognitive strategies will be more effective for improving recall of both spatial attributes and complete elements of the maps. The predicted rank order of effect was: training (most effect), instructions, task, control.

3) There will be no reliable difference between the four treatment groups for the improvement in the recall of verbal labels of the maps.

4a) Those learners with low general aptitude scores and low performance on the pretest should benefit less from the instruc-

BEST COPY AVAILABLE

tions, task, and control inducements of strategy use than will those learners with high scores and performance. The less explicit the inducement of metacognitive strategies, the more deficit that will be displayed by the lower aptitude learners;

4b) Learners at all levels of general aptitude will benefit equally from the most explicit inducement of effective strategy use (i.e. the training group).

5) The recall of the map attributes will be reliably correlated with performance on the comprehension test.

6) Those learners who receive the more explicit inducements of attention and metacognitive strategy use will increase their use of these procedures more than learners receiving less explicit inducement.

7) The use of metacognitive strategies will correlate reliably with the increment in map recall from the pretest to the posttest.

8) The effectiveness of the training group treatment will not be dependent on visual memory ability, as measured by the Building Memory Test.

Results

The design of this study resulted in a large volume of data being produced. In order to ease interpretation of this mass of information, this section will be organized into sections that relate to the eight a priori hypotheses listed above. The level of rejection for all tests was set a priori at .05. Whenever justified by theory, a priori orthogonal contrasts were used in lieu of the overall F test for the analysis of variance. All types of statistical

analysis were performed using SPSS procedures.

Pretraining Strategy Use: The prediction of more use of both metacognitive and attention strategies by successful learners was confirmed for the metacognitive strategies only. The data here do not support the Thorndyke and Stasz finding that "good" learners spontaneously use more of the "effective" attention strategies. In fact the learners in this study actually used less of one of these procedures (stochastic sampling). High performance learners did spontaneously use more of four of the five metacognitive strategies (general evaluation, unlearned elements, immediacy, and planning) and less of the one ineffective attention strategy (random sampling). While the Thorndyke and Stasz study had shown that their successful learners used more of all three spatial encoding strategies, this finding was confirmed only for relations encoding ($p<.01$) in the current study.

Treatment Effects: The following orthogonal contrasts were established for the treatment effects:

	control	task	instructions	training
Contrast #1	3	-1	-1	-1
Contrast #2	0	-1	+1	0
Contrast #3	0	-1/2	-1/2	1

The overall treatment hypothesis was not supported, in that the first two planned contrasts failed to reach significance. The first contrast had predicted that those groups which received any type of instructional inducement from the treatment (whether embedded or detached) would outperform the group with totally self-assigned strategies (the control group). This comparison failed

because the task and instructions groups did not outperform the control group on either spatial or complete element recall.

The second planned contrast predicted that the general detached inducement of strategy use (the instructions group) would be more effective than embedded inducement (the task group). In fact, the task group outperformed the instructions treatment group on the final trial; otherwise the two groups performed at about the same level. Neither of these inducements involving self-assignment of lesson induced strategies resulted in greater improvement than that of the control group.

The final planned contrast confirmed the hypothesis that the training group treatment would be superior ($p=.025$). This means that the most explicit inducement of strategy use (involving supplantation of specific effective procedures) was more effective than either of the less explicit methods of inducing effective strategy use. A graph of the treatment results is presented as Figure 6.

Recall of Verbal Attributes: The prediction of no reliable difference on this measure was largely confirmed by the results. All groups except the task group actually declined on the recall of verbal attributes. Only the task group showed significantly higher verbal recall on the posttest. However, all four groups attained very high verbal recall scores, with the range of average verbal element recall spreading across a very narrow range (19 to 21 attributes). Per-trial data indicated that the task group had a significant verbal recall advantage on only one of the five trials.

Effects By Pretest Performance: To test this interaction, affiliation (either from the high aptitude pool of learners or the

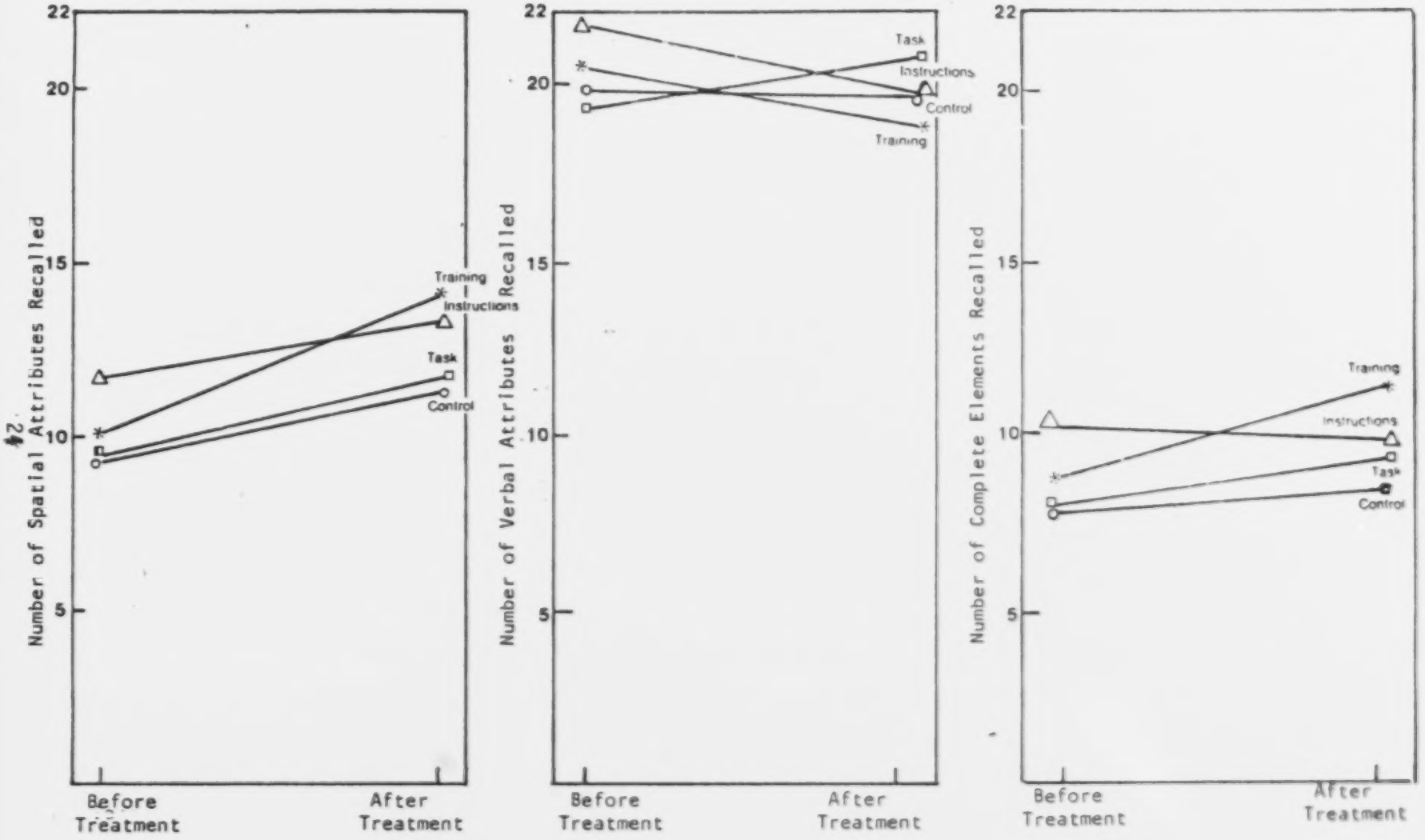

Figure 6: Average Recall of Spatial Attributes, Verbal Attributes, and Complete Elements on the Pretest and Posttest.

low) was added as a blocking variable to the original analysis of treatment effects. The overall treatment effect was not significant; that is, the two affiliations did not differ in their responses to the first three treatments (control, task, and instructions).

The second part of this hypothesis was confirmed, however; the training group treatment was reliably effective for subsamples of learners which were widely varied in their entering aptitudes and performance. In fact, the lower aptitude learners showed the greatest improvement in the recall of complete map elements, averaging an increase of nearly one element more per trial than the high aptitude learners. In addition, the raw score increment in average recall represented a 64% increase in performance for low aptitude learners and only a 14% increase for high aptitude learners.

Validity of the Recall Scores: All types of recall were highly correlated with all three types of knowledge measured by the comprehension test ($p<.001$ for all correlations). The within-group data indicated that the correlations for the training group were noticeably higher than those for the other three groups, reaching $r=.94$ for the correlation of last trial complete recall with the total comprehension score (compared with a range of .60 to .79 for the other three groups).

Posttest Strategy Use: Of particular interest to this study is whether or not the treatments induced learners to use effective strategies on the posttest, regardless of their strategy use on the pretest. The presumption is that the advantage displayed by the training group is accounted for by that group's increased use of the effective procedures trained.

All groups were induced to change their pattern of strategy use. In fact, all four groups increased their use of at least two of the target successful procedures. All four groups also spontaneously increased their use of one of the effective spatial encoding strategies (relation encoding). Although all four groups increased their use of some target procedures, the training group was the only group to change its use of strategies in the expected direction for all categories; that is, those learners decreased their use of the neutral and ineffective strategies at the same time that they increased their use of the effective spatial, attention, and metacognitive strategies (see Table 2 for a complete summary).

Correlation of Strategies With Recall Performance: If the strategies which were trained actually caused the increment in recall, then the use of those strategies during the second session should correlate highly with the recall increment for those in the training group. To test this assumption, the increment in recall from the first map to the second was correlated with the use of effective strategies. A correlation matrix indicated that only the metacognitive strategies and relation encoding exhibited a consistently positive relationship with performance (with relation encoding exhibiting a strong relation to the metacognitive measures, $r=.62$, $p<.001$). The results indicate that both strategy-use measures have a strong relationship with performance only for the training group ($r=.39$ to $.55$).

Effect of Visual Memory Ability: One of the main intents of training metacognitive strategies was to bypass the effect of

Table 2
Comparison of Strategy Use on the Pretest and the Posttest

Strategy	Group									
	All learners		Control		Task		Instructions		Training	
	Pre	Pst	Pre	Pst	Pre	Pst	Pre	Pst	Pre	Pst
Mean frequency of strategy use										
Neutral strategies										
Rehearsal	2.84	2.90	3.24	2.88	2.40	3.12	2.92	2.56	2.80	3.04
Association 1	1.94	1.56*	2.08	1.56	2.12	2.00	1.52	1.20	2.04	1.48
Association 2	3.21	2.59**	3.04	3.00	3.36	2.84	3.36	2.56*	3.08	1.96**
Association 3	1.05	0.58**	0.80	0.60	0.80	0.72	1.56	0.68**	1.04	0.32**
Mneumonics	1.16	0.80**	1.32	0.96	1.08	0.64*	1.20	0.52**	1.04	1.08
Labeling	0.67	0.58	0.64	0.68	0.76	0.48	0.76	0.68	0.52	0.48
Counting	3.21	3.16	3.52	3.20	2.88	3.28	3.68	3.32	2.76	2.84
Ineffective strategies										
Random sampling	2.31	1.74**	2.08	1.88	2.28	1.80*	2.40	2.16	2.48	1.12**
Spatial strategies										
Imagery	3.63	3.83	3.88	3.96	3.88	4.40	3.16	3.32	3.60	3.64
Pattern encoding	3.51	3.85*	3.72	3.60	3.12	3.80*	4.00	4.48*	3.20	3.52
Relations encoding	3.84	4.55**	3.64	4.40*	3.80	4.44*	4.16	5.00*	3.76	4.36*
Attention strategies										
Spatial partitioning	3.51	4.05*	3.88	4.20	4.00	3.64	3.12	3.52	3.04	4.84**
Conceptual partitioning	4.09	4.00	3,72	4.08	3.96	3.72	5.00	4.92	3.68	3.28
Stochastic sampling	3.23	3.36	2.76	3.48	3.52	3.12	3.32	3.20	3.32	3.64
Systematic sampling	2,25	2.47	2.12	2.16	2.80	2.80	2.00	2.32	2.08	2.60
Metacognitive strategies										
General evaluation	4.46	4.93**	4.56	5.00	4.80	5.28*	4.60	5.00	3.88	4.44**
Unlearned elements	4.39	4.80	4.84	4.48	4.40	4.80	4.36	5.16*	3.76	4.76**
Immediacy	4.27	4.61*	4.04	4.36	4.00	4.44*	4.84	4.84	4.20	4.80
Planning	2.89	3.90**	2.68	3.44*	3.32	3.96*	2.92	3.80*	2.64	4.40**
Completion	3.54	4.15**	3.36	4.08**	4.08	4.08	3.68	4.08	3.04	4.36**

*p<.05
**p<.01

entering ability differences. A linear regression of performance increment on the Building Memory Test scores indicated that this ability accounted for only 2% of spatial, 1% of verbal, and 0% of complete recall ($F<1$). The training group treatment was effective for learners at all levels of visual memory ability.

Implications

The results lend support to the theory which asserts that successful learners tend to use cognitive strategies which emphasize the application of planning, monitoring, and evaluation skills. The findings add to the previous theory by suggesting that it may be possible to overcome initial capacity limitations by inducing learners to apply effective metacognitive learning strategies. It appears that the explicit supplantation of such strategy use is far more effective than the simple activation of those same strategies. The significance of the findings is added to by the fact that the successful training group treatment consisted of merely twenty minutes of practical instruction in a typical group classroom setting.

Strategy Use: This study joins with the Thorndyke and Stasz research in confirming the tendency of successful learners to plan, evaluate, and correct their study behaviors. The use of metacognitive strategies explained both the success of spontaneously good learners on the pretest and the increase in performance of those who were more successful on the posttest. Successful learners report that they used metacognitive procedures "most of the time".

Attention strategies were not as effective as anticipated. Either they are not as influential as suggested by previous studies

or they are dependent on the planning, control, and monitoring of metacognitive strategies.

The Explicitness of Inducement: This study lends strong support to the assertion that very explicit inducement of strategy use is necessary for most learners. Only detailed modeling of specific strategies met with success; learners were not able to generate or activate their own strategies either in response to task information or in response to general instructions. Although subjects in all groups changed their pattern of strategy use at least partially in the correct direction, such changes were ineffectual in all but the training group. Only the strategy changes exhibited by the training group correlated with success, indicating that only this group successfully applied the effective strategies selected. Strategy changes for the training group were highly consistent and purposeful. The very brief duration of the most explicit inducement of strategy use (45 minutes including practice) suggests that explicit inducements of learning strategy use need not be either elaborate or time consuming.

The Effects of Entering Aptitude: Previous instructional research has often found that lower aptitude learners are less successful than higher aptitude learners at being able to take advantage of changes in instructional materials and techniques intended to assist them. The results of this study are important because the training of metacognitive strategies was equally effective for learners whose SAT scores, visual memory ability, and entering performance ranged across more than four standard deviations. The training group treatment was equally effective regardless of entering performance on similar tasks, level of visual

memory ability, sex, or source of subject.

Conclusion

This study should encourage researchers to further explore the trainability of cognitive learning strategies. Metacognitive strategies in particular seem to show promise, as this study indicates that they may be more influential than lower level strategies and that they appear to be highly trainable. Although poor learners cannot spontaneously use or induce the use of effective metacognitive strategies, it seems very easy for them to grasp both their significance and application when they are specifically trained.

It may be that our schools and training programs are overemphasizing content skills to the exclusion of general thinking skills. It may be possible to train general cognitive skills which have broad applicability to a wide range of tasks, and which are independent of either aptitude or the specific attributes of instructional materials.

REFERENCES

Alesandrini, K. Pictorial-verbal and analytic-holistic learning strategies in science learning. Journal of Educational Psychology, 1981, 73 (3), 358-368.

Anderson, R., Spiro, R., & Montague, W. (Eds.). Schooling and the Acquisition of Knowledge. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977.

Bobrow, D. & Norman, D. Some principles of memory schemata. In D.G. Bobrow, & A. Collins (Eds.), Representation and Understanding. New York: Academic Press, 1975.

Booher, H. Relative Comprehensibility of Pictorial Information and Printed Words in Proceduralized Instructions. Human Factors, 1975, 17 (3), 266-277.

Boutwell, R., & Barton, G. Toward an adaptive learner controlled model of instruction: a place for the new cognitive aptitudes. Educational Technology, 1974, 14 (5), 13-18.

Bovy, R.C. Successful instructional methods: a cognitive information processing approach. Educational Communications and Technology Journal, 1981, 29 (4), 203-217.

Brown, A.L. Development, schooling, and the acquisition of knowledge about knowledge: comments on chapter seven by Nelson. In R.C. Anderson., R. Spiro, & W. Montague (Eds.), Schooling and the Acquisition of Knowledge. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977.

Brown, A.L. Knowing when, where, and how to remember: a problem of metacognition. In R. Glaser (Ed.), Advances in Instructional Psychology (Vol. 1). Hillsdale, N.J.: Lawrence Erlbaum Associates, 1978.

Carroll, J.B. Psychometric tests as cognitive tasks: a new "structure of intellect". In L. Resnick (Ed.), The Nature of Intelligence. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1976.

Curcio, F., & Smith-Burke, M.T. Processing information in graphical form. Paper presented at the annual meeting of the American Educational Research Association, New York, 1982.

Das, J., Kirby, J., & Jarman, R. Simultaneous and successive syntheses: an alternative model for cognitive abilities. Psychological Bulletin, 1975, 82 (1), 87-103.

Das, J., Kirby, J., & Jarman, R. Simultaneous and Successive Cognitive Processes. New York: Academic Press, 1979.

Derry, S. Strategy training: an incidental learning model for CAI. Journal of Instructional Development, 1985, 8, (2), 16-23.

Ekstrom, R., French, J., & Harman, H. Kit of factor-referenced cognitive tests. Princeton, N.J.: Educational Testing Service, 1976.

Estes, W.K. The state of the field: general problems and issues of theory and metatheory. In W.K. Estes (Ed.), Handbook of Learning and Cognitive Processes (Vol. 1). Hillsdale, N.J.: Lawrence Erlbaum Associates, 1975.

Flavell, J.H. Metacognitive aspects of problem solving. In L.B. Resnick (Ed.), The Nature of Intelligence. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1976.

Flavell, J.H. Metacognition and cognitive monitoring. American Psychologist, 1979, 34, 906-911.

Gagne', R.M. The Conditions of Learning. New York: Holt, Rinehart, and Winston, 1965.

Gick, M., & Holyoak, K. Analogical problem solving. Cognitive Psychology, 1980, 12, 306-355.

Glaser, R. Components of a psychology of instruction: toward a science of design. Review of Educational Research, 1976, 46 (1), 1-24.

Glaser, R. Advances in Instructional Psychology. (Vol. 1). Hillsdale, N.J.: Lawrence Erlbaum Associates, 1978.

Glaser, R., & Resnick, L. Instructional Psychology. Annual Review of Psychology, 1972, 23, 207-276.

Gropper, G.L. The design of stimulus materials in response-oriented programs. Audio-Visual Communications Review, 1970, 18, (2), 129-159.

Heidt, E.U. Differences between media and differences between learners: can we relate them? Instructional Science, 1980, 9, 365-391.

Holliday, W.G. Teaching verbal chains using flow diagrams and texts. Audio-Visual Communications Review, 1976, 24, (1), 63-78.

Klahr, D. (Ed.). Cognition and Instruction. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1976.

Macdonald-Ross, M. Graphics in texts. Review of Research In Education, 1977, 5, 45-85.

Mathews, N., Hunt, E., & Macleod, C. Strategy choice and strategy training in sentence-picture verification. Journal of Verbal Learning and Verbal Behavior, 1980, 19, 531-548.

Merrill, M.D. Learner control: beyond aptitude treatment interactions. Audio-Visual Communications Review, 1975, 23 (2), 217-226.

Moray, N. The strategic control of information processing. In G. Underwood (Ed.), Strategies of Information Processing. London: Academic Press, 1978.

Newell, A., & Simon, H. Human Information Processing. Englewood Cliffs: Prentice Hall, 1972.

Norman, D. Notes toward a theory of complex learning. In A.M. Lesgold, J.W. Pellegrino, S.D. Fokkema, & R. Glaser (Eds.), Cognitive Psychology and Instruction. New York: Plenum Press, 1978.

O'Neil, H., (Ed.). Learning Strategies. New York: Academic Press, 1978.

Polya, G. Mathematical Discovery. New York: John Wiley and Sons, 1967.

Rigney, J.W. Learning strategies: a theoretical perspective. In H.F. O'Neil (Ed.), Learning Strategies. New York: Academic Press, 1978.

Rigney, J.W. Cognitive learning strategies and dualities in information processing. In R.E. Snow, P.A. Federico, W.A. Montague, (Eds.), Aptitude, Learning, and Instruction, (Vol. 1). Hillsdale, N.J.: Lawrence Erlbaum Associates, 1980.

Salomon, G. Heuristic models for the generation of aptitude-treatment interaction hypotheses. Review of Educational Research, 1971, 42, (3), 327-343.

Salomon, G. Interaction of Media Cognition and Learning. San Francisco: Jossey-Bass, 1979.

Shuell, T.J. Learning theory, instructional theory, and adaption. In R.E. Snow, P.A. Federico, W.A. Montague, (Eds.), Aptitude, Learning, and Instruction, (Vol. 2). Hillsdale, N.J.: Lawrence Erlbaum Associates, 1980.

Simutis, A. Army applications of learning strategies research. Paper presented at the annual meeting of the American Educational Research Association, New York, 1982.

Snow, R.E. Theory and method for research on aptitude processes: a prospectus. Technical Report #2, Aptitude Research Project, School of Education, Stanford University, 1976. (ERIC Document Reproduction Service No. 142198).

Snow, R.E. Aptitude processes. In R.E. Snow, P.A. Federico, W.A. Montague, (Eds.), Aptitude, Learning, and Instruction, (Vol. 1). Hillsdale, N.J.: Lawrence Erlbaum Associates, 1980.

Stasz, C. Planning during map learning: the global strategies of high and low visual-spatial individuals (N-1594-ONR). Santa Monica, CA: Rand Corporation, 1980.

Stasz, C., & Thorndyke, P. The influence of visual-spatial ability and study procedures on map learning skill (N-1501-ONR). Santa Monica, CA: Rand Corporation, 1980.

Sternberg, R., & Weil, E. Aptitude x strategy interaction in linear syllogistic reasoning. Journal of Educational Psychology, 1980, 72, (2), 226-239.

Thorndyke, P.W. Performance models for spatial and locational cognition. (R-2676-ONR). Santa Monica, CA: Rand Corporation, 1980.

Thorndyke, P.W., & Stasz, C. Training procedures for map learning (N-1018-ONR). Santa Monica, CA: Rand Corporation, 1979.

Thorndyke, P.W., & Stasz, C. Individual differences in procedures for knowledge acquisition from maps. Cognitive Psychology, 1980, 12, 137-175.

Weinstein, C. Cognitive Elaboration Learning Strategies. Austin, Texas: Texas University, 1977. (ERIC Document Reproduction Service No. ED 144 953).

Winn, W. Visual information processing: a pragmatic approach to the "imagery question". Educational Communications and Technology Journal, 1980, 28, (2), 120-133.